

## Claims

What is claimed is:

1. An accelerometer, comprising:
  - a measurement mass for detecting acceleration, including:
    - a housing having a cavity;
      - one or more spring mass assemblies positioned within the cavity, each spring mass assembly including:
        - a support structure;
          - one or more resilient folded beams coupled to the support structure; and
        - a mass coupled to the resilient folded beams; and
        - one or more electrode patterns coupled to the spring mass assembly;
      - a top cap wafer coupled to the measurement mass, including a top capacitor electrode; and
      - a bottom cap wafer coupled to the measurement mass, including a bottom capacitor electrode.
2. The accelerometer of claim 1, wherein one or more of the spring mass assemblies further include:
  - one or more range-of-motion stops coupled to the support structure for limiting the movement of the mass in the direction of the stops.
3. The accelerometer of claim 2, wherein one or more of the range-of-motion stops include one or more perforations for minimizing fluid damping.
4. The accelerometer of claim 2, wherein one or more of the range-of-motion stops are coupled to the side walls of the support structure.

1 5. The accelerometer of claim 2, wherein one or more of the range-of-motion stops  
2 are coupled to the interior corners of the support structure.

1 6. The accelerometer of claim 1, wherein one or more of the resilient folded beams  
2 include:  
3 one or more range-of-motion limit stops for limiting movement of the  
4 mass in the direction of the stops.

1 7. The accelerometer of claim 1, wherein one or more of the folded beams further  
2 include:  
3 a mass for dampening out resonances of the resilient folded beam.

1 8. The accelerometer of claim 1, wherein one or more of the spring mass assemblies  
2 further include:  
3 one or more soft range-of-motion limit stops for compliantly limiting  
4 movement of the mass in the direction of the stops.

1 9. The accelerometer of claim 1, wherein one or more of the spring assemblies  
2 further include:  
3 corner tethers for coupling the corners of the mass to the opposing interior  
4 corners of the support structure.

1 10. The accelerometer of claim 1, wherein one or more of the resilient folded beams  
2 further include one or more cutouts for minimizing stress concentrations.

1 11. The accelerometer of claim 1, wherein one or more of the resilient folded beams  
2 further include one or more cutouts for minimizing webbing formation during the  
3 manufacture of the folded beams.

1 12. The accelerometer of claim 1, wherein one or more of the resilient folded beams  
2 further include a webbing artifact having a hole for preventing the propagation of

3 cracks into the resilient folded beams.

1 13. An accelerometer, comprising:  
 2 a measurement mass for detecting acceleration, including:  
 3 a housing having a cavity;  
 4 one or more spring mass assemblies positioned within the cavity,  
 5 each spring mass assembly including:  
 6 a support structure;  
 7 one or more resilient S-shaped beams coupled to the  
 8 support structure; and  
 9 a mass coupled to the resilient S-shaped beams; and  
 10 one or more electrode patterns coupled to the spring mass  
 11 assembly;  
 12 a top cap wafer coupled to the measurement mass, including a top  
 13 capacitor electrode; and  
 14 a bottom cap wafer coupled to the measurement mass, including a bottom  
 15 capacitor electrode.

1 14. The accelerometer of claim 13, wherein one or more of the spring mass  
 2 assemblies further include:  
 3 one or more range-of-motion stops coupled to the support structure for  
 4 limiting the movement of the mass in the direction of the stops.

1 15. The accelerometer of claim 14, wherein one or more of the range-of-motion stops  
 2 include one or more perforations for minimizing fluid damping.

1 16. The accelerometer of claim 14, wherein one or more of the range-of-motion stops  
 2 are coupled to the side walls of the support structure.

1 17. The accelerometer of claim 14, wherein one or more of the range-of-motion stops  
 2 are coupled to the interior corners of the support structure.

18. The accelerometer of claim 13, wherein one or more of the S-shaped beams include:

one or more range-of-motion limit stops for limiting movement of the mass in the direction of the stops.

19. The accelerometer of claim 13, wherein one or more of the S-shaped beams further include:

a mass for dampening out resonances of the resilient folded beam.

20. The accelerometer of claim 13, wherein one or more of the spring mass assemblies further include:

one or more soft range-of-motion limit stops for compliantly limiting movement of the mass in the direction of the stops.

21. The accelerometer of claim 13, wherein one or more of the spring assemblies further include:

corner tethers for coupling the corners of the mass to the opposing interior corners of the support structure.

22. The accelerometer of claim 13, wherein one or more of the S-shaped beams further include one or more cutouts for minimizing stress concentrations.

23. The accelerometer of claim 13, wherein one or more of the S-shaped beams further include one or more cutouts for minimizing webbing formation during the manufacture of the S-shaped beams.

24. The accelerometer of claim 13, wherein one or more of the S-shaped beams further include a webbing artifact having a hole for preventing the propagation of cracks into the S-shaped beams.

- 1        25.    An accelerometer, comprising:  
2            a measurement mass for detecting acceleration, including:  
3                a housing having a cavity;  
4                    one or more spring mass assemblies positioned within the cavity,  
5                    each spring mass assembly including:  
6                        a support structure;  
7                            one or more resilient straight beams coupled to the support  
8                                structure; and  
9                            a mass coupled to the resilient straight beams; and  
10                        one or more electrode patterns coupled to the spring mass  
11                        assembly;  
12                    a top cap wafer coupled to the measurement mass, including a top  
13                        capacitor electrode; and  
14                    a bottom cap wafer coupled to the measurement mass, including a bottom  
15                        capacitor electrode.
- 1        26.    The accelerometer of claim 25, wherein one or more of the spring mass  
2            assemblies further include:  
3                one or more range-of-motion stops coupled to the support structure for  
4                    limiting the movement of the mass in the direction of the stops.
- 1        27.    The accelerometer of claim 26, wherein one or more of the range-of-motion stops  
2            include one or more perforations for minimizing fluid damping.
- 1        28.    The accelerometer of claim 26, wherein one or more of the range-of-motion stops  
2            are coupled to the side walls of the support structure.
- 1        29.    The accelerometer of claim 26, wherein one or more of the range-of-motion stops  
2            are coupled to the interior corners of the support structure.

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- 1 30. The accelerometer of claim 25, wherein one or more of the straight beams  
2 include:  
3 a range-of-motion limit stop for limiting movement of the mass in the  
4 direction of the stop.
- 1 31. The accelerometer of claim 25, wherein one or more of the straight beams further  
2 include:  
3 a mass for dampening out resonances of the straight beam.
- 1 32. The accelerometer of claim 25, wherein one or more of the spring mass  
2 assemblies further include:  
3 one or more soft range-of-motion limit stops for compliantly limiting  
4 movement of the mass in the direction of the stops.
- 1 33. The accelerometer of claim 25, wherein one or more of the spring assemblies  
2 further include:  
3 corner tethers for coupling the corners of the mass to the opposing interior  
4 corners of the support structure.
- 1 34. The accelerometer of claim 25, wherein one or more of the resilient folded beams  
2 further include one or more cutouts for minimizing stress concentrations.
- 1 35. The accelerometer of claim 25, wherein one or more of the resilient folded beams  
2 further include one or more cutouts for minimizing webbing formation during the  
3 manufacture of the resilient folded beams.
- 1 36. The accelerometer of claim 25, wherein one or more of the straight beams further  
2 include a webbing artifact having a hole for preventing the propagation of cracks.
- 1 37. An accelerometer, comprising:

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S-shaped beam.

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41. The method of claim 40, further including:

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limiting movement of the measurement mass.

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42. A method of operating an accelerometer having a measurement mass positioned

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within a housing including top and bottom electrodes positioned between

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corresponding top and bottom capacitor electrodes, comprising:

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resiliently coupling the measurement mass to the housing using a straight

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beam.

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43. The method of claim 42, further including:

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limiting movement of the measurement mass.

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44. A method of preventing crack propagation in a micro-machined structure

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including a webbing artifact, comprising:

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providing one or more holes within the webbing artifact.

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45. A method of minimizing backside etching of elements within a micro-machined

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structure, comprising:

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providing one or more etch-buffers adjacent to the elements.

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46. A method of improving the dimensional uniformity of elements within a micro-

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machined structure, comprising:

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providing one or more etch-buffers adjacent to the elements.

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47. A method of protecting a mass supported within a support structure by one or more springs, comprising:

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providing one or more soft-contact bumpers for preventing impacts

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between the mass and the support structure.





48. A sensor package, comprising:

(a) a sensor having a mass suspended by a plurality of springs which induce mechanical vibrational modes in the sensor, the sensor providing an output signal indicative of acceleration detected by the mass;

(b) a controller coupled to the sensor in a closed-loop configuration, the controller in response to the output signal of the sensor providing a digital output proportional to the acceleration detected by the sensor, the controller in the closed-loop operation having at least one predefined frequency band for stable operation relative to the frequency of mechanical vibrational modes induced in sensor; and wherein the plurality of springs are tuned so that the frequency of the induced mechanical vibrational modes remains substantially within at least one predetermined frequency band.

49. The sensor package of claim 48, wherein the sensor is tuned by selecting one of (i) shape of the springs, (ii) mass of the springs, (iii) size (dimensions) of the springs; and (iv) a combination of at least two of the shape, size and mass of the springs.

50. The sensor package of claim 48, wherein the springs are selected from a group consisting of (i) folded beam springs; and (ii) s-shaped springs.

51. The sensor package of claim 48, wherein the springs are further selected to maintain a spring constant within a predetermined range.

52. The sensor package of claim 51 wherein the spring constant is selected as a function of at least one of (i) sensitivity and frequency response of the sensor; (ii) dynamics range of the sensor output; and (iii) desired shock tolerance of the sensor.

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